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EDITORIAL

A proposal for a systematic classification of airway devices similar to the Linnean taxonomy

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Anything that evolves over time might be viewed from an evolutionary perspective. The technical development of airway instruments has evolved in a similar manner: introduction of a simple solitary new tool initiates a totally novel category of equipment and in so doing offers yet unseen opportunities for further developments. Each significant innovation is usually followed by an avalanche of variants possessing new features and improved functionality. Sometimes fairly minor changes to the basic design are made primarily to capitalise on improvements in economic benefits, but in general, the remorseless laws of evolution with their basic mechanisms: mutation (variation, change) and selection, unshakeably result in the disappearance of unsuitable material and a tendency for the fittest, which are the most successful ones to prevail. The application of a taxonomical approach when seeking to create order in the world of airway devices is not just an idle pastime. It might help to establish an insight into what is currently a very crowded collection of airway management instruments. However, taxonomy needs to be applied according to the established methods of classification that were developed in a structured and logical manner by the famous Swedish botanist, physician, and zoologist Carl Linnaeus (1707-1778) in his monumental work of taxonomy of living creatures [1]. He used taxonomic units, known as “taxa”, which he arranged in a hierarchical classification scheme. He developed an order of ranks to permit the categorisation of the constituent species, subspecies, families and super-families depending on the variation and distribution of common key features that he has recognized as the denominators of relatedness between the involved units. The resulting inter-relationships between the subjects are therefore recognized as having a common origin based on the growth of a single developmental tree with various branches of increasing complexity. Some branches effectively run directly from their early origins to recently existing forms, however, many more appear to have stopped in a blind ending in the past, thus marking the curtailment and extinction of less successful variants. The same principle can be applied to understand the evolution in the development of airway management devices.

The first airway device with a proven potential for longevity, Dr Morton’s ether inhaler, appeared in the middle part of the 19th century. The conduit representing the *interface* between the ether-soaked sponge retained inside a glass bottle and the patient, was a mouthpiece. This mouthpiece can be considered as the earliest and

simplest airway device that fulfilled both basic requirements for anaesthesia: 1. to connect the human airway to a source of gas flow (or a specific volume of air containing ether vapour as it was then), and 2. to offer at least the basic prospect to observe inhaled gas (and hence vapour) channelled into and out of the patient's airway. The simplest *interface* used in current anaesthetic practice as a conduit between the patient's airway and the gas delivery system is the face mask. Hence this can be regarded as the most generic existing analogy to Morton's mouthpiece, and the genealogical source of the evolutionary tree of airway devices. Essentially, this is the origin from which all other airway devices have been derived.

When applied correctly, the underlying principle governing the use of a facemask is the ability to maintain a gas-tight seal with the patient, which, if it can be achieved, works well in the majority of cases. The natural limitations of the face mask (and of its precursors such as the ether masks of those times) prompted the development of a more invasive device that might reliably improve performance and patient safety. The result was the tracheal tube introduced independently and nearly simultaneously in different places by O'Dwyer and Kuhn [2, 3]. Initially, placement of the tracheal tube was performed in a blind fashion by direct manual insertion, but this proved to be very difficult and in times of uncontrolled reflex activity, dangerous as well! To overcome this, the first laryngoscopes comprising a handle, a blade and a light source were developed 1895 by Kirstein [4]. By acknowledging the tracheal tube and the laryngoscope, we have identified the first essential instruments that have been so well conceived in their design concepts and of time-honoured utility that they continue to underpin the principles governing techniques for securing the airway both in anaesthesia and beyond. These two instruments also represent each of the dual principles applied to airway devices; They can be classified as either "gas channelling" devices to facilitate oxygen and anaesthetic gas delivery, such as the tracheal tube, or as "introducers" (i.e. devices that facilitate the introduction of an airway management device normally under visual control) such as the laryngoscope. For this reason we can apply this distinction to all other airway devices and classify them either as a "channeller" (by being a descendant of the tracheal tube), or an "introducer" (by being a descendant of the direct laryngoscope). As usual in science, one can simplify the nomenclature of complex terms by using abbreviations and combining them to form acronyms. Likewise, this can be done in the taxonomy of airway devices by using abbreviations for typical basic features thus facilitating the

creation of certain taxonomic clades and subclades. These can be organized in hierarchical order starting with domain, kingdom, phylum, class, order, family, genus, and ending with distinct Species. Within the species, there can be various subspecies and races.

With regard to the taxonomy of airway devices, one can allocate the first position (as first of 4 hierarchical levels) of the acronym a “C” for all *channellers* (such as tracheal tubes) or an “I” for all *introducers* (such as laryngoscopes). This level can be viewed as a “domain”, either I or C. The 2nd level reflects the fundamental difference such as the entry place for channellers and the basic technique of introducers; this level can be called the “family”. The 3rd level might represent the species and the 4th the subspecies, both based on elements that differentiate all the devices at that specific level. In contrast to the living world, here we cannot invoke the rule that the absolute requirement to produce fertile descendents defines subsequent development of the species.

Channelling devices

Close review of the channellers’ identifies immediate derivatives of the original tracheal tubes through observation of their main distinguishing “family” criterion: the point of introduction of the tube into the airway. Here we have 3 variants: the oral route (O), the nasal route (N) and the trans-tracheal route (T). This permits us to apply the respective abbreviations as CO for the orally inserted tube, CN for the nasal and CT for the tracheostomy tube. The denomination is more specific when we arrive at the “species” level when we add the position of the distal opening as related to the glottis: O for “oral”, S for supraglottic, I for infraglottic (but above the carina), and finally C for beyond the carina. A reference to the distinction between supra- and peri-glottic openings is ignored here for the sake of simplicity and because the difference represents a relatively minor technical detail. A secure airtight seal can be created by blocking any leak around the device by inflating a cuff. Tubing that does not possess a cuff creates an exception and therefore a difference in classification. To acknowledge this distinction at the sub-species level, one can add a B for a cuffed (blocked) device and a U for an uncuffed device. According to this, the regular (uncuffed) oro-pharyngeal airway becomes COOU [5] whilst the now “extinct”

cuffed version that briefly appeared in the nineties only to disappear soon after, would be classified as a COOB [6]. Consequently a list of the most widespread channelling instruments with their 4 character acronyms can be constructed and represented thus:

COOU - channelling, oral insertion, oral opening, uncuffed: e.g. oro-pharyngeal airway (e.g. Guedel tube)

COOB - channelling, oral insertion, oral opening, cuffed: e.g. the meanwhile extinct C.O.P.A. (Cuffed oro-pharyngeal airway)

COSB - channelling, oral insertion, supraglottic opening, cuffed: e.g. laryngeal mask airway or laryngeal tube [7, 8]

COSU - channelling, oral insertion, supraglottic opening, uncuffed: e.g. iGel or SLIPA [9, 10]

COIB - channelling, oral insertion, infraglottic opening, cuffed: e.g. conventional (oro)-tracheal tube

COIU - channelling, oral insertion, infraglottic opening, uncuffed: e.g. uncuffed (paediatric) oro-tracheal tube

COCB - channelling, oral insertion, subcarinal opening, cuffed: e.g. double lumen tube

CNSU - channelling, nasal insertion, supraglottic opening, uncuffed: e.g. naso-pharyngeal airway (e.g. Wendl tube)

CNIB - channelling, nasal insertion, infraglottic opening, cuffed: e.g. (naso-tracheal tube

CTIB - channelling, transtracheal insertion, infraglottic opening, cuffed: e.g. tracheostomy tube

CTIU - channelling, transtracheal insertion, infraglottic opening, uncuffed: e.g. uncuffed tracheostomy cannula

The ‘channelling’ element of the airway devices’ family tree is represented in Figure 1.

Introducing devices

When we switch to the family of introducers, an analogous system can be created to represent the variants within this heterogeneous group of devices. Here we have two equally populated subgroups (families) of introducer devices: laryngoscopes (L) and stylets (S). Laryngoscopes can be divided into 2 species: the direct type (labelled D - an example of this type would be the conventional laryngoscope), and the indirect visualisation type, represented by devices with an optical (older fashion) or, more recently, video assisted visualisation capability, labelled with V. Meanwhile, at the species level we have a rather large group of video assisted laryngoscopes, which differ among each other by having a tube guiding facility (G) or not having this (U) thus representing 2 sub-species. With regard to the stylet family, we can distinguish those which are used in a “blind” fashion (N for non-visualizing); including gum elastic bougies, soft tip-guidewires, tube exchangers and countless other locally used stylets. Conversely, visualising stylets (labelled V) can be either rigid (R) such as the Bonfils intubation stylet, or flexible (F) such as the flexible intubation fiberoptic endoscope. A third variant of visualising stylets is the hybrid or composite type (C) in which rigid and flexible elements are integrated in one instrument such as the SensaScope [11]. As demonstrated with the channellers, we can categorise all the well known introducers in a similar manner with their respective acronyms:

- **ILDU** - introducer, laryngoscope, direct viewing, without tube guiding facility: e.g. the classical direct laryngoscope such as the Macintosh, Miller [12, 13]
- **ILVG** - introducer, laryngoscope, video assisted, with tube guiding facility: e.g. Airtraq, Pentax AWS
- **ILVU** - introducer, laryngoscope, video assisted, without tube guiding facility: e.g. Glidescope [14]
- **ISNR** - introducer, stylet, non-visual, rigid: e.g. rigid guidewire to stiffen tracheal tubes
- **ISNF** - introducer, stylet, non-visual, flexible: e.g. gum elastic bougie, COOK tube exchanger [15]

- **ISVR** - introducer, stylet, visual, rigid: e.g. Bonfils intubation stylet
- **ISVF** - introducer, stylet, visual, flexible: e.g. flexible fiberoptic bronchoscope
- **ISVC** - introducer, stylet, visual, composite: e.g. SensaScope [11]

Hence an overview of the ‘introducers’ family tree is represented in Figure 2:

Both introducers and channellers can be combined in a single taxonomic diagram to illustrate the whole taxonomy. However, such a representation does become somewhat crowded even though the diagram does not include every variant of every device previously used for airway management. An overview of the interrelationship among airway management devices is represented in Figure 3.

Previously both, Brimacombe and Miller, have proposed detailed classifications of supraglottic airway devices organized according to their respective features and their chronological introduction [16, 17]. These summaries, although detailed, only focus their attention on specific classes of airway devices. The taxonomic system I present here attempts to provide a comprehensive overview embracing the entire range of airway management devices; although such a broad remit is inevitably at the expense of incorporation of every detail. The creation of such a classification structure does facilitate the incorporation of new instruments with features common to some of the existing devices and also provides the opportunity to incorporate future devices, which are developed to include novel features that are as yet unrecognised. The acronyms used in this classification have been allocated according to a logical systematic appraisal of known airway management devices. It should be acknowledged that while the acronyms may not necessarily be easily memorized or achieve widespread recognition, the system does provides a useful overview of all airway device categories and can be adapted to accommodate future developments.

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Figures

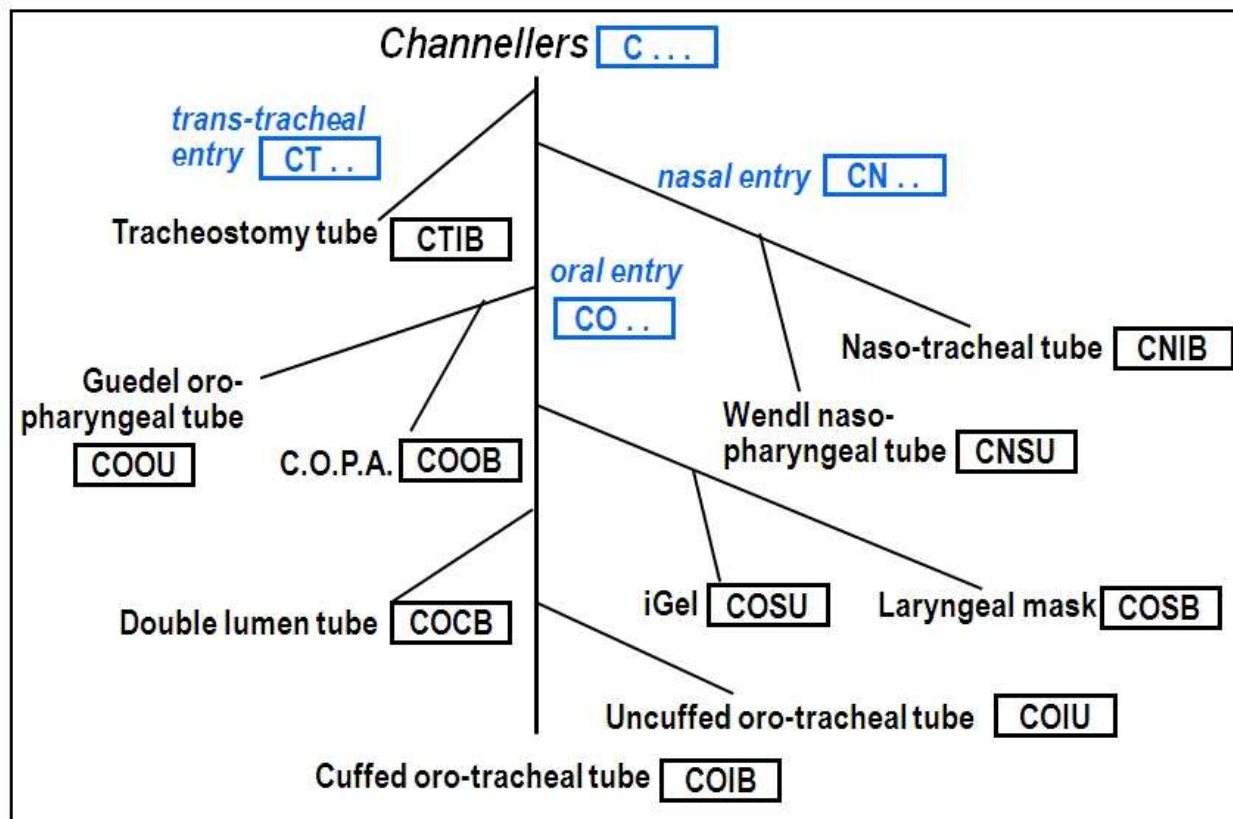


Fig. 1. Family tree of the “channellers” domain naming typical instruments and their taxonomic acronyms. The entries in blue represent general principles underlying the classification.

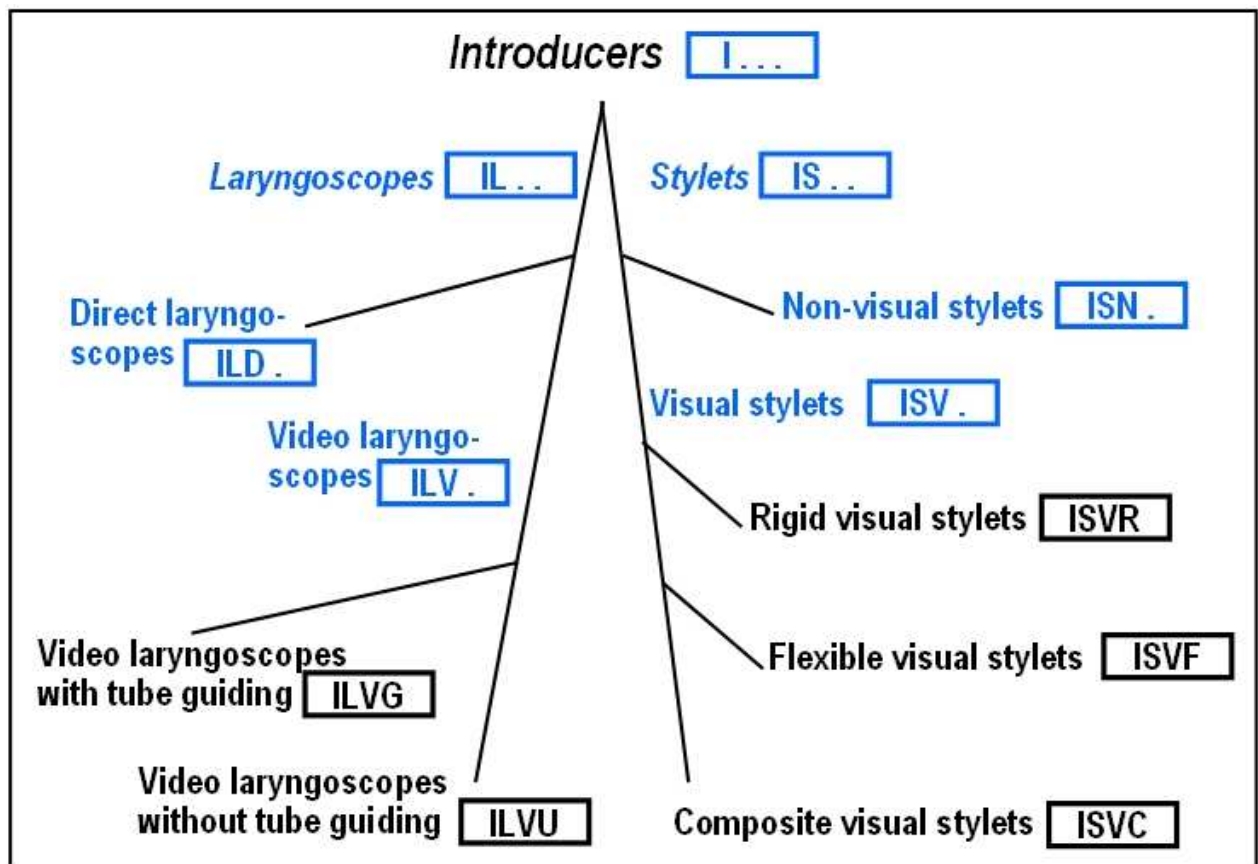


Fig. 2. Family tree of the “introducers” domain naming typical instruments and their taxonomic acronyms. The entries in blue represent general principles underlying the classification.

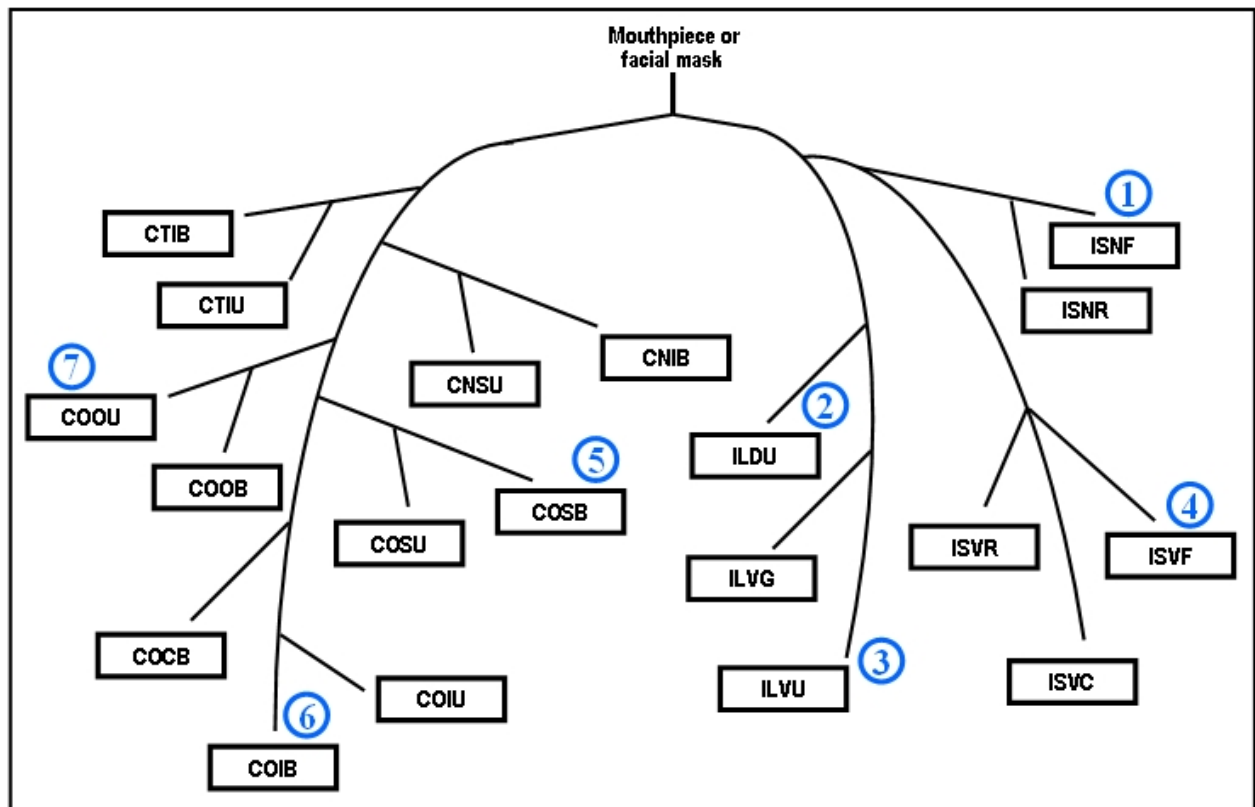


Fig. 3. Overview on all types of airway devices with their taxonomic acronyms. Blue encircled numerals highlight some popular instruments such as: 1. Gum elastic bougie, 2. Classical direct laryngoscope, 3. Glidescope, 4. Flexible fiberoptic, 5. Laryngeal mask airway, 6. Conventional tracheal tube, 7. Pharyngeal airway (Guedel).